Although the preceding information reflects recent research on the hearing sensitivities of some marine mammal species, little is actually known about the hearing sensitivities of many other species. Moreover, much of what is known is based on the frequencies in which marine mammals vocalize. Marine mammals could easily hear sound frequencies at which they do not vocalize. Moreover, equipment used to record marine mammal vocalizations is usually designed to record within the human range of hearing, which is from about 20 Hz to 20 kHz. As explained earlier, some marine mammals may be able to detect sounds as low as 5 Hz, while others may pick up sounds as high as 180 kHz. It has even been said that some marine mammals seem to be able to detect low frequency sounds better than the electronic devices we utilize (Richardson *et al.* 1995). Thus, any assumptions made about the hearing sensitivities of various marine mammal species must be tempered with caution.

Most birds hear quite well in the range of 100 Hz up to 10 kHz. Moreover, birds can probably detect loud, very low frequency sounds (Bowles 1995). Considering this, it is likely that birds could also be harassed by airborne and underwater sounds of a detonation or pile driving operation.

Sufficiently loud noises can evoke a startle response, which means just what it implies: a sudden reaction to a stimulus. Such a reaction can be caused by an animal hearing a sound and/or being struck by the wave of overpressure. With marine mammals, a startle response can be manifested by a flinch or sudden movement or by evasive maneuvers or even panic. The relative severity of the response can have legal implications. A simple startle response in which no harm is done would not be considered a severe impact and would be considered Level B harassment under the MMPA. A startle response that led to an exodus of seals into the water in which pups were trampled would be considered a take under the MMPA. This is not to say this would occur, but rather to illustrate that assessing the relative severity of a startle response is important.

More severe impacts include hearing damage. Such damage has been categorized in two ways: temporary hearing [threshold] shift (TTS) and permanent [hearing] threshold shift (PTS). In TTS, an animal's ability to hear is temporarily diminished through part or all of its hearing range. The diminishment in hearing can last for minutes, hours, days, or weeks. As a familiar example, humans sometimes suffer TTS after enduring a loud rock concert, but their hearing usually returns to normal after a few hours. With marine mammals and sea turtles, the damage can range from very temporary impairment to actual physical damage that takes weeks to heal. Birds are able to recover comparatively swiftly even after significant damage has occurred (Corwin and Cotanche 1988; Ryals and Rubel 1988).

In PTS, an animal's ability to hear is permanently affected throughout part or all of its hearing range. PTS obviously constitutes a more significant take in the case of marine mammals. With most birds, the problem is less acute and may not be life-threatening. With diving birds, however, rupture of the tympanic membrane can lead to water entering the inner ear and causing severe problems. With all animals, physical damage to the ear can result in infection, which in turn can lead to complications and even mortality.

When animals are subjected to significant underwater sound pressure waves, physical injuries can occur. Gas spaces can rapidly compress and decompress, causing internal bleeding, ruptures and/or tissue damage. Such damage, while not necessarily fatal, can lead to infections and further complications. Such damage can also make an animal more vulnerable to predators. The crystalline lens of the eye can also be damaged, inducing blindness if the injury is severe. Animals that are close to a detonation or pile driving operation can be killed.

Diving birds are considerably more vulnerable than marine mammals to underwater detonations. When such birds are on the surface, however, they are considerably less vulnerable because very little of their bodies are exposed and much of the energy of the sound pressure wave is reflected by the sea surface and by air trapped in the feathers.

Impacts upon fish depend upon the type of fish subject to underwater detonations or pile driving operations. Most bony fish have swim bladders, gas-filled sacs that ensure neutral buoyancy. With swim bladder fish, the bladder can expand very rapidly after being compressed by the sound wave of a detonation, resulting in the fish floating to the surface, where they are vulnerable to predators. Eye damage and protruding intestines characterize more serious damage to fish. Nonetheless, fish are less affected by underwater sounds at a given range than are marine mammals and diving birds.

Some bony fish, like flatfish and cartilaginous fish, lack swim bladders and are considerably less vulnerable to the effects of underwater sounds. Much of their body is made of water, which is incompressible, so sound pressure waves simply travel through them. For the same reason, a similar phenomenon occurs with many invertebrates.

Most of the chemicals in the explosives will be consumed during the detonations. Most byproducts of the detonations consist of gases, which will rise to the surface very rapidly and dissipate into the atmosphere. Any chemical residues left in the water will quickly dissipate. Considering the small size of the charges and the rapid dissipation of any residues, no measurable potentially harmful chemicals will exist. Moreover, the detonations will not cause any geysers of water to shoot skyward; instead, the detonations will simply produce moderate-sized circles of bubbles, which will swiftly disappear.

3.4.3 Pile Driving

Pile driving can generate very loud concussive sounds underwater. If the sounds are sufficiently loud, all of the impacts discussed in the previous section are possible. The greatest risk of impact from pile driving would probably come from the steady blows of the hammer as each pile was driven, possibly resulting in Level B harassment. Sound levels generated by pile driving depend upon the following factors, among others:

- The shape and size of the pile, including its wall thickness if it is hollow;
- The pile material;
- The size and energy of the pile driving hammer;
- The repetition rate of the hammer;
- The water depth;
- The composition of the substrate;
- How deep the piles will driven into the sea floor;
- The bathymetry of the area; and
- Physical oceanography (e.g., temperature, salinity and thermoclines).

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Several of these factors are known. The piles are made of round hollow steel and are 30 inches in diameter and approximately 1.5 inches thick (Lorentz, pers. comm.). The water depth at the project site is 32 feet deep at mean lower low water. The sea floor is covered with varying thicknesses of sand and sediments (from no sand to three to four feet of sand) on top of Monterey shale, which graduates from weathered to solid material with depth (ARCO 2003). The piles will be driven to a depth of 15 feet into the Monterey formation, or less if sufficient resistance is encountered to adequately anchor the piles (Lorentz, pers. comm.). The nearby bathymetry has been charted (Fugro 1999). The physical oceanography can be generalized from available literature. The hammer specifications are not available at this time, however, except that the hammer generates 242,000-377,000 foot-pounds (328 to 511 kilojoules [kJ]) of energy (Lorentz, pers. comm.).

Prior to a recent pile-driving project on the beach at PRC-421, Greene (2001a and b) conservatively estimated that a sound pressure level of 160 dB re 1µPa - rms would be attained at a range of 374 feet. This was a sound pressure threshold that was considered by the regulatory agencies to be safe for baleen whales at the time (please see Appendix 2 for an explanation of sound pressure level measurements and applications to mitigation). The piles were driven through sand into Monterey shale. They were driven on the beach, however (Lorentz, pers. comm.). Moreover, the piles were only 12 inches in diameter rather than 30 inches. Finally, no measurements were made of the actual sound levels generated by the pile driving. The same type and size of pile driver was used in Carpinteria in one to three feet of water depth, but no measurements were obtained of the sound levels from that operation, either (Howorth 2001). The pile drivers for the two projects generated between 9,500 to 18,000 foot-pounds of energy (13 to 24 kJ) (Lorentz, Pers. comm.). No marine mammals were impacted by either project.

These projects are the only recent examples of steel pile driving operations in Santa Barbara County. Unfortunately, however, the information cannot be applied to this project because:

- No sound level measurements were made during either project;
- Considerably more energy will be necessary to drive a 30-inch pile than was required for a 12-inch pile; and
- Considerably more energy will be coupled into the water column in 32 feet of water than from on the beach or in 1 to 3 feet of water.

Extensive measurements were made during a pile-driving demonstration for the replacement of the east span of the San Francisco-Oakland Bay Bridge. In this case, an enormous pile driver was used in deep water to drive a steel piling eight feet in diameter into mud. The pile driver generated 1,250, 392 foot-pounds (1700 kJ) of energy. Considering the size of the pile and pile driver, the water depth, and the composition of the sea floor (mud rather than sand and shale), these data cannot be applied to this project, either. The San Francisco Bay project is discussed as another potential source of information that was examined but proved not applicable to this project.

TABLE 2: ENERGY LEVELS FROM PILE DRIVING PROJECTS

Project	Foot-pounds	Kilojoules (approximate)
Ellwood 421 Pier	9,500-18,000	13-24
Venoco Carpinteria Gas Pipe Supports	9,500-18,000	13-24
Hong Kong Airport Fuel Facility	55,380	90
ARCO PRC-421 Piles (proposed)	242,000-377,000	328-511
San Francisco-Oakland Bay Bridge	1,250,392 (maximum)	1700 (maximum)

Sources: Wursig *et al.* 2000; Greene 2001a and b; Lorentz, pers. comm.

Considering the overall lack of applicable sound pressure level data on pile driving, measurements will be made of pile driving sounds for this project to assess the effectiveness of the proposed hazard zone (please see section 4.11)

3.4.4 Placement of Quarry Rock

The placement of quarry rock will produce low frequency sounds that could result in extremely localized Level B harassment of marine mammals. The sounds would be transmitted through the water as the rocks slid across the deck of the barge, splashed into the water and landed on the sea floor. Such sounds would be localized and short-lived because the rock will be placed in only three days. No significant impacts are anticipated from the placement of quarry rock

3.5 Wildlife Species of Concern

3.5.1 Marine Mammals

Some 42 species of marine mammals have been reported in the region (Leatherwood *et al.* 1983; Leatherwood *et al.* 1987; Caretta *et al.* 2001 and 2002). These are summarized in Tables 1-4 in Appendix 1. Of the 42 species, most are offshore species that seldom come close to the coast. Considering that the project site is only 850 feet offshore, only coastal species are likely to be encountered there. The few species that may appear at or near the project site are described below, in order of probability of occurrence.

Pacific harbor seals: Pacific harbor seals *(Phoca vitulina richardsi)* are very common in the project area because a sizable rookery, sometimes inhabited by more than 100 individuals, exists about one mile west of the project site (Sadler 1976; Rambo 1978; Bowland 1978). Harbor seals number 30,293 individuals in California (Caretta *et al.* 2001 and 2002). They have their pups in winter, most of which arrive in February and March. A few are born sooner, from December through February, and occasionally a pup is born as late as May. The pups nurse for four to six weeks, then are abandoned by their mothers. No nursing pups will be present during the project.

The presence of harbor seals has been noted in hazard zones during past projects in the region, sometimes causing short delays until they swam out of the area. Harbor seals will be encountered during this project.

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